DII-2017-049

Waste Control and Management System in Polokwane Capricorn Municipality District of South Africa

Modupe Cecilia Mewomo[1], Clinton Ohis Aigbavboa[2], Molebogeng Rozyne Maja[3]

Abstract

The management of waste generated from the construction activities is a critical issue requiring serious and adequate attention. Construction waste constitutes nuisance to the construction environment and could lead to negative public impression of the construction industry as well as poor project performance, if not properly managed. Thus, this paper investigates the measures that can be taken for effective management of construction waste in the Polokwane municipality of South Africa. Data were collected using a questionnaire design. The targeted respondents were the contractors who are involve in various types of construction activities in Polokwane. Based on factors identified from the review of literature, the respondents were asked to rate the methods and measures that can be adopted for the effective control of construction waste in Polokwane. A total number of 44 questionnaires were obtained and were analysed using statistical package for the social sciences (SPSS). Mean value was used to determine the level of significant of each identified factor.The study revealed fifteen measures that could be put into consideration for effective waste management system in Polokwane. These measures include, on site management systems, implementation of environment management system, implementation of a waste reduction framework plan, standardization of design to improve buildability, reduction in quantity off-cuts, waste auditing to monitor and record environmental performance on-site, provision of an on-site sorting facilities, controlling land fill area, legislation control, stock control measures, quantities flexibilities measures, education and awareness measures, just-in-time delivery measures, penalty for poor site waste management and employment of specialist waste managers. The adoption of these measures would go a long way in enhancing efficient construction project performance in Polokwane District of South Africa.

Keywords: construction waste, waste control, waste management, Polokwane, South Africa

[1]Post-doctoral fellow; Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; modupemewomo@gmail.com.
[2]Associate Professor; Department of Construction Management and Quantity Surveying; University of Johannesburg; University of Johannesburg, South Africa; coaigbavboa@uj.ac.za.
[3]Graduate Student; Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa

1. Introduction

Waste generated during different stages of construction activities is one of the serious problems in construction industry at large (Nagapan et al., 2011). The construction waste constitutes nuisance to the construction environment and also lead to negative public impression of the construction industry (Adewuyi and Odesola, 2015). Moreover, poor planning and inadequate control of these construction waste lead to poor project outcome and poor project performance in the construction industry (Jayamathan and Rameezdeen, 2014). Thus, there has been serious concern about the volume of waste generated in the construction industry (McDonald and Smithers, 1998). One of the major problem of construction waste is the poor manner at which the waste generated from the construction activities are being handled. For instance, the report of Gauteng Department of Agriculture Conservation and Environment (GDACE, 2009) reveals that the majority of construction waste in Gauteng province of South Africa is being disposed of either illegally or to landfill. This action has a serious potential environmental impact on the country and all relevant stakeholders. Some notable consequences of illegal dumping and disposal to landfill include environmental degradation, poor public image of construction industry, increase demand for landfill, pollution, resources and material loss among others (GDACE, 2009). While it is true that, it is impossible to completely avoid construction waste, proper control and effective management of these waste are very necessary (Teo and Loosemore, 2001). It is on this background that this study investigates the measures that can be put in place for the effective waste management practice in Polokwane district of South Africa.

2. Construction Waste and its Impacts on the Environment

The construction industry plays an important role in the growth of any national economy and contributes meaningfully to the development of relevant stakeholders. Notwithstanding its importance, the industry has particularly been noted for its contribution to environmental degradation not only in South Africa but also in most other countries across the globe (Ali et al, 2014). The impact of the construction industry in terms of the resources it consumes and the waste it generates has been widely acknowledged (Tam, 2007, GDACE, 2009). Literature reveals that 50% of municipal solid waste in developing countries comes from construction (Lu and Yuan, 2011). In fact, more than 50% of waste entering land fill in the United Kingdom (UK) originates from construction (Ferguson et al., 1995). Similarly, research reports from Australia reveals that 44% of the total waste being deposited in landfilled annually is coming from the construction industry (McDonald, 1996; Craven et al., 1994) In South Africa, although there is limited published information on the composition and volume of construction waste generated at different provincial level, the observations have shown that construction and demolition sites generate substantial commingled wastes (Purnell, 2009, GDACE, 2009). For instance, the reports of the Department of Agriculture Conservation and Environment on the waste generated in the Gauteng Province of South Africa shows that 20% of waste generated within the province arise from building demolition and construction waste. The report further indicates *inter alia* that approximately one quarter (25%) of waste entering landfills are building and demolition waste. Unfortunately, based on an analysis of waste generation in nine South African provinces, there is an indication that waste generation continued to increase in all provinces over the last decade (SAEO) (South Africa Environment Outlook, 2012). The increase volume of construction waste generation has attracted considerable attention in the recent times (Lauritzen, 1998; Ali et al, 2014). The major concern lies on the fact that most of the waste generated from construction ends up in landfills or at times illegally dumped (GDACE, Gauteng Department of Agriculture Conservation and Environment, 2009). Thus the increase in the amount of

waste generated and the lack of appropriate waste control and management system has become an issue of major concern in all countries including South Africa and Polokwane Municipality (Ikau et.al., 2016; Jawad and Omar, 2016, SAEO, 2012). The official country problem statement according to the National Waste Management Strategy (NWMS) (Department of Environmental Affairs 2012) has highlighted 10 major challenges faced by South Africa in the waste management field. According to this reports, the major challenges include, the increase in the population has resulted in increased volumes of waste generated, the increased complexity waste stream due to industrialization, Inadequate waste services lead to unpleasant unhealthy environment; policy and regulatory environment that does not actively promote the waste management hierarchy, growing pressure on outdated waste management infrastructure, with declining levels of capital investment and maintenance among others. The increase in construction activities usually leads to increase in the waste generated from construction. Thus, it is expected that all effort should be put in place for effective management of the waste produced. Several consequences accompany ineffective waste management system notably are the fact that it leads to environmental degradation, encourages further dumping which aesthetically degrade the landscape, increase pollution, reduction in the amount of natural resources and increase burden on scarce land resources GDEAC, 2009). Having realised that construction waste constitutes nuisance to the construction environment and could lead to negative public impression of the construction industry as well as poor project performance, the need for comprehensive strategies to reduce waste through more efficient planning and good management system becomes very necessary.

3. Strategies for Controlling Construction Waste

Strategies for controlling construction wastes have been the subject of several research projects. As identified from previous studies, most of the problems concerning waste on building are related to flaw in management system (Formoso et al., 1999). Thus there has been several calls for effective waste management. Waste management encompasses collection, transporting, storage, treatment, recovery and disposal of waste (Hwang, 2011). It involves waste minimisation and effective waste control strategies. According to Ferguson et al. (1995) there are three waste minimisation strategies that can be used on construction projects. These are, reduce, reuse and recycle. El-Haggar (2007) developed waste management hierarchy framework and noted that waste management plan involves five steps which are reduce, reuse, recycle, recover and disposal. The benefit associated with the adoption of this framework include cost saving, reduction in the demand for landfill, construction industry image improvement, productivity and quality improvement, and better resource management (Hwang, 2011). Poon et al., (2004) emphasised the need to adopt certain measures in order to reduce waste. He further noted the need to implement measures at the planning and construction stages in order to avoid and minimise waste generation. Such planning includes preparation of a detailed waste management plan as well as implementing waste control measures at the construction stage. According to him, this measures should include a good housekeeping and on-site sorting of inert from non-inert materials, which enable reuse and recycling. In addition to his findings, many other researchers have highlighted other measures needed to be in place for the effective waste management on construction sites. Some of these measures includes: legislative control, controlling public filling facilities, controlling landfill areas, providing on-site sorting facilities, implementation of an environmental management system, implementation of a waste reduction framework plan, standardization of design to improve ability and reduce the quality of off-cuts, stock control measures to avoid the over ordering of materials and just in time delivery strategy (McDonald and Smithers, 1998; Poon et al., 2001; Shen et al., 2002; WDO, 2006).

4. Research Methodology

This study employed a quantitative research approach. Data were collected using a questionnaire design. The questionnaire formulation begins with a review of related literature to identify possible measures that can be adopted for the effective control of construction waste. From the literature review, sixteen potential measures were identified and were presented in a questionnaire form for survey. The questionnaire design consists of two main sections. The first was the introductory section which was design to collect the background information of the respondents. The second section is the principal section which requested the respondents to appraise the significance level of each of the identified factors as possible measures that can be adopted for the effective management of construction waste. The respondents were to judge the significance on a predefined 5 point Likert scale (1=Strongly Disagree, 2=Disagree. 3=Neutral, 4=Agree and 5= Strongly Agree). Based on the ranking given to each of the factors by the respondents, MIS score was obtained for each of the identified factors and were ranked from highest to lowest. An hypothesised mean of 3.5 was used as relevant level determinant as used in some earlier studies (Ahadzie *et al.*, 2008). Thus, a factor is considered relevant if it has a mean item score of 3.5 or more.

Since the focus of this research is on management of waste generated from construction activities in the Polokwane municipality of SA, the sample for the study were randomly drawn from the construction professionals who are involve in various types of construction activities and their firms are duly registered in the Polokwane Capricorn Municipality District. The target respondents were contractors, builders, engineers, project managers and site agents who operates at the senior level in all categories of construction firms visited. These respondents were asked to rate the methods and measures that can be adopted for the effective control of construction waste in Polokwane. The research survey attracted 44 responses and they were analysed using SPSS. The analysis shows that respondents are involved at both private and public construction sectors of the industry. Further, the analysis shows that 29.5% of the respondents were site agents/foreman, 31.9.4% were project managers, 22.7% were engineers, and 15.9% were Construction Managers. The years of experience of the participants varies, 79.5% had experience that ranged from 1-5 years, 18.2% had experience in the range 6-10 years and 2.3% had experience that ranged between 11-15 years. The analysis further revealed that 52.3% had worked in 4-10 projects, 36.4% had worked in 11-15 projects, 6.8% had worked in 16-25 projects, 2.3% had worked in 1-3 projects and 2.3% had worked in more than 25 projects. This demographic information implies that the respondents have involved in a number of projects within the province and are suitable for this type of project which make the data reliable.

5. Results and Discussion

As aforementioned, the mean item score (MIS) was utilised in the analysis of respondents' perceptions of the relevance of each factor identified as measure that can be taking for effective waste control and management system. The MIS takes into account each factor's frequencies as being the perceived potential measure that can be employed for effective waste control in Polokwane. For the purpose of clarity and better presentation of the agreement reached by the respondents, the mean item score and ranking of each factor were tabulated. A summary of the analysis results is shown in Table 1. In addition, the mean item score for each factor, including the associated standard deviation, is also reported In Table 1. Consequently, based on the five-point Likert scale, a factor was deemed very significant if it has a mean item score of 3.5 and above. In the situation where two or more factors have

the same mean item score, the factor with the lowest standard deviation was allotted the highest importance ranking.

From Table 1, it was revealed that on site management systems ranked first with a MIS of 4.59, implementation of an environment management system ranked second with a MIS of 4.55, implementation of a waste reduction framework plan ranked third with a MIS of 4.45 while standardization of design to improve build ability and reduce the quantity off-cuts, waste auditing to monitor and record environmental performance, provision of an on-site sorting facilities, controlling land fill area, design management to prevent over specification of material, legislation control, stock control measures, supply quantities flexibilities measures, use of contractual clauses to penalised waste poor management performance, dedicated specialist sub-contract package for on-site waste management, education and awareness measures, just-in-time delivery measures were ranked fourth, fifth, sixth, seventh eight, ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteen and seventh respectively. It is very important to note that the results of this study offer an interesting observation in that all the factors with exception of the last factor named 'Just in time delivery strategy' have a MIS that is higher than hypothesised mean of 3.5.

Table 5: Measures for controlling construction waste

MEASURES FOR CONTROLLING CONSTRUCTION WASTE	MIS	SD	RANK
On site management system	4.59	0.658	1
Implementation of an environment management system	4.55	0.791	2
Implementation of a waste reduction framework plan	4.45	0.730	3
Standardization of design to improve build ability and reduce the quantity of off-cuts	4.41	0.984	4
Waste auditing to monitor and record environmental performance on –site	4.36	0.892	5
Controlling landfill areas	4.34	0.963	6
Providing on-site sorting facilities	4.34	1.010	7
Design management to prevent the over specification of materials	4.30	0.904	8
Legislative control	4.23	0.937	9
Stock control measures to avoid the over ordering of materials	4.20	0.954	10
Supplier flexibility in providing smaller quantities of materials	4.05	0.872	11
Contractual clauses to penalize poor waste performance	3.98	0.876	12
Dedicated specialist sub-contract package for on-site waste management	3.75	0.967	13
Educate clients about the measures to reduce waste levels	3.68	1.196	14
Controlling public facilities	3.50	0.952	15
Just in-time delivery strategy	3.23	1.292	16

Consequently, a cursory evaluation of the order at which these factors are ranked may suggest priorities and level of relevance attributed to each of the factors by the professionals' as waste control measure. However, it is important to note that the fifteen factors are having very high MIS and the MIS are close to each other. This is an indication that there is possibly no discernable difference in the level of relevance attached to the identified potential measures. This implies that though the potential measure factors can be prioritized, all the fifteen factors are potential measures that can be adopted for effective control of waste on construction projects. A careful observation of the first three factors identified as the potential measure for waste control by the professionals shows that they can be grouped under source reduction measure. Source reduction has been advised and in most countries taken as highest priority (Ali *et al.*, 2014). In the hierarchy of waste management, reduction of waste is to be considered first due to the fact that it provides economic benefits by reducing the costs associated with

transportation and disposal (Tam, 2008; Wang et al, 2010). Thus, the management system of source reduction, reuse, recycling, and landfilling are very important (Wang et al, 2010).The waste management hierarchy put emphasis on reduction, reuse, recycle and disposal. It is therefore very important to educate all relevant construction stakeholders so that they can have adequate knowledge that can promote effective waste management within the construction industry.

6. Conclusion

The measure that can be adopted for an effective waste management system was examined in this study based on the potential waste control measured that were identified from the literature. The study revealed fifteen measures that could be put into consideration for effective waste management system. These measures include on site management systems, implementation of environment management system, implementation of a waste reduction framework plan and education of various construction participants on the importance of adequate waste control and management system. Thus, the study adds to the body of knowledge by providing information on measures that can be adopted for effective construction waste management in Polokwane district in South Africa. The adoption of these measures would go a long way in enhancing efficient construction project performance in Polokwane district of South Africa. It is very important to note that this paper is limited to Polokwane district professionals, and as such affects its generalization. This limitation suggests wider study of this investigation within South Africa.

References

Adewuyi T. O., and Odesola I. A. (2015). Factors Affecting Material Waste on Construction Sites in Nigeria. *Journal of Engineering and Technology* (JET), 6(1), 82-99.

Ahadzie D K, Proverbs D G and Olomolaiye P (2008). "Critical success criteria for mass house building projects in developing countries". *International Journal of Project management*, (26): 675-687.

Ali A N, Asma Z, Farideh J, Mohammad V and Ahmad Z (2014) "A study identifying causes of construction waste production and applying safety Management on construction site." *Journal of health sciences* **2**(3): 49-54.

Craven E J, Okraglik H M and Eilenberg I M (1994) "Construction waste and a new design methodology." *Proceedings of the first Conference of CIB TG 16: Sustainable Construction*: 6-9 November 1994, Tampa, Florida, USA, 89-98.

DEA (Department of Environmental Affairs), (2012) *National Waste Management Strategy*. Department of Environmental Affairs, Pretoria.

El-Haggar S M (2007) Sustainable industrial design and waste management: Cradle to Cradle for sustainable development, Elsevier Academic Press, Maryland Height, MO.

Ferguson J, Kermode N, Nash C L, Sketch W A J and Huxford R P (1995) *Managing and minimizing construction waste: a practical guide*, London, Telford.

Ferguson J, Kermode N, Nash C L, Sketch W A J and Huxford R P (1995) Managing and Minimizing Construction Waste – A Practical Guide. Institution of Civil Engineers: London.

Formoso C T, Isatto E L, Hirota, E H (1999) Method for waste control in the building Industry, Proceedings IGLC-7 325-334

GDACE (Gauteng Department of Agriculture Conservation and Environment Gauteng Provincial Building and Demolition Waste Guidelines) (2009) available at www.gdard.gpg.gov.za/Services1/Building_and_Demolition_Waste_Guideline.doc [Accessed 12/03/2017]

Hwang B G, and Bao Yeo Z. (2011). Perception on benefits of construction waste management in the Singapore construction industry. Engineering, Construction and Architectural Management, 18(4): 394-406.

Ikau R, Joseph C and Tawie R (2016) "Factors Influencing Waste Generation in the construction industry in Malaysia" *International Conference on Quality of Life*, 25- 26 February, 2016, Medan, Indonesia.

Jawad A and Omar A (2016) "Understanding the key factors of Construction Waste in Jordan" *Jordan Journal of Civil Engineering*, **10** (2): 244 - 252.

Jayamathan J and Rameezdeen R (2014) Influence of labour Arrangement on Construction material waste generation" *Structural survey*, **32**(2): 76-88.

Lauritzen E K (1998) Emergency construction waste management, *Safety Science* **30**(1-2): 45-53.

Lu W and Yuan H (2011) "A framework for understanding waste management studies in construction. Waste Management, 31(6): 1252-1260.

McDolnald B and Smithers M (1998) "Implementing a waste management plan during the construction phase of a project: a case study" *Construction Management and Economics* **16**(1): 71-78.

McDonald B (1996). "RECON waste minimisation and environmental program." *Proceedings of CIB Commission Meetings and Presentations*, Melbourne, Australia, 14-16.

Nagapan S, Abdul-Rahman I, and Asmi A (2011) "A review of construction waste cause factors", *In Asian Conference on Real Estate* 2011, 3-5 October 2011, Thistle Hotel Johor Bahru, Malaysia

Purnell G (2009) 'National waste quantification and waste information system'. *Department of Environmental Affairs*, Pretoria.

SAEO (South Africa Environment Outlook, 2012) "Waste Management", Draft 2 version 3 available at http://soer.deat.gov.za/dm_documents/Chapter_9__Waste_Management_wHOt0.pdf [Accessed 12/03/2017).

Shen L Y, Tam V W Y and Tam C M (2002). Material Wastage in Construction Activities – A Hong Kong Survey. Proceedings of the CIB W107 1st International Conference: Creating a Sustainable Construction Industry in Developing Countries. Stellenbosch: South Africa

Tam V W (2008) "On the effectiveness in implementing waste management plan method in construction" available at https://research-repository.griffith.edu.au/bitstream/handle/10072/24123/51944_1.pdf?sequence=1 [Accessed 17/04/2017].

Tam V W Y (2007) "Implementing a waste management plan in construction, Fourth International Conference on Construction in the 21st Century (CITC-IV) "*Accelerating Innovation in Engineering, Management and Technology*" July 11-13, 2007, Gold Coast, Australia available at https://research-repository.griffith.edu.au/bitstream/handle/10072/24123/51944_1.pdf?sequence=1 [Accessed 16/04/2017].

Teo M M and Loosemore M (2001) "A theory of waste behaviour in the construction industry", *Construction Management and Economics*, **19**(7): 741-751.

Wang J, Yuan H, Kang X and Lu X. (2010) "Critical success factors for on-site sorting of construction waste: a China study", *Resources, Conservation and Recycling* **54**(11): 931-936.

Waste Disposal Ordinance (WDO, 2006) Homepage, available at http://sc.info.gov.hk/gb/www.epd.gov.hk/epd/misc/ehk03/textonly/eng/waste/7_6.html